# HOROLOGIOGRAPHIA NOCTVRNA.

OR

# *LVNAR HOROLOGIOGRAPHIE.*

Set forth and demonſtrated (after a twofold manner) in the Horizontall Plane onely.

Vpon which (and all other by the ſame reaſon) may in a manner, as plainely and ſpeedily bee diſcerned the times of the Night by the Gnomonicall ſhadow, cauſed by the Moone, as the times of the Day upon any by the Sun: Serving as well in the day time for the Sunne.

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*By* IOHN WYBERD.

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Together with an Addition of certaine new and briefe Rules for the exact and moſt ſpeedy menſuration of Circles and Spheres, and alſo Cylinders, both in ſolid and liquid meaſure, by certaine plaine Scales onely, not heretofore publiſhed, but now ſet forth for the benefit of all thoſe that have occaſion to make uſe of ſuch things.

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*Eſt natura hominum novitatis avida.* Plin.

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# A DESCRIPTION OF THE HORIZONTALL *LUNAR DYALL.*

THe making of this Dyall dependeth upon the moſt uſuall obſervation of the Moones Mediation of the Heaven, or comming to the Meridian, as the little Note or Table here following doth ſhew; and which Maſter *Digges* in his generall *Prognoſtication*, Mr. *Hopton* in his *Concordancie* of Yeares, and moſt others have and doe ſtill chiefely obſerve and follow: Which obſervation or rule, although it ſeemeth not alwayes to hold very preciſe, by reaſon of the various and ſundry motions of the Moone, yet is it not ſo much amiſſe, or diſſenting from the truth, but that the time of the night (the Moone ſhining) may be thereby ſufficiently knowne, without any ſenſible error to be regarded, as the afore named Authors (accounted good Mathematicians in their times, and which their workes doe ſtill teſtifie) have in thoſe bookes ſet downe without any ſtricter obſervations: And as I my ſelfe alſo have very often obſerved, when the Moone hath ſhined upon an

*Horizontall* or other Sun-Dyall, by the ſhaddow of the Style or *Gnomon*, and comparing the ſame with other ſufficient wayes, have found them to accord without any plainely perceptible difference: For having ſearched out the true time of the Moones mediating, or culminating of heaven, for any night, appointed in a place certaine (which is not very eaſily done) the true houre at any time of that night may be found, the Moone ſhining upon any true Sun-Dyall in the ſame place: Becauſe the defect or exceſſe of the ſtylar ſhadow in time, in reſpect of the houre of 12. upon the Dyall, being deducted from, or added to the aforeſayd time, giveth the true houre or time of that night: which thing although it be well knowne to many (as a common rule) yet unknowne to moſt men, for every man is not acquainted with the Moones ſayd mediation, or hath knowledge artificially to get the times of the ſame, and none but ſuch as have ſome ir ſight into aſtronomicall affaires, or perhaps knowing the ſame by ſome ordinary meanes (as many doe) yet cannot readily make ſubduction or addition of the ſayd defect, or exceſſe (as occaſion ſhall require) unleſſe the ſame doe chance to fall juſtly upon ſome abſolute and entire time on the Dyall, at the time of obſervation, and therefore it muſt needes be very convenient to have a Dyall, that ſhall even as readily (without any trouble) ſhew the houre of the night by the Moone, as the houre of the day by the Sunne: So that the time of the Moones comming to the Meridian (whatſoever time it be) is preſuppoſed to ſtand in the Meridian line or line of North and South on the Dyall, in the place of the houre of 12. which time being fore-knowne for any night appointed: If the houre-lines be ſo drawne on the Plane (in a due order) that the time of the Moones comming to the Meridian, ſhall fall preciſely in the ſayd Meridian line, or line of North and South: I ſay then that theſe houre-lines being thus diſpoſed, ſhall readily and preciſely enough ſhew the houre of the ſame night, at any time thereof when it ſhall be required, if the Moone ſhineth on the Plane: yet it muſt not be expected that any Dyall ſhould bee made (for continuance) to ſhew the houre of the night by the Moone alwayes ſo exactly as the houre of the day by the Sun,

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by reaſon of the various courſe and motion of the Moone, in reſpect of the Sun, as before is ſayd; but exactly enough for ordinary uſe: And hereupon is framed this Dyall, which here wee have in hand, according to this little Note or Table, hereto annexed as I ſayd before: In the firſt columne whereof, are contained the dayes of the Moones age, reckoned from the time of her change, or conjunction with the Sunne: In the ſecond is contained the time of her comming to the Meridian or South point, anſwering to each day of her age; for although the Moone being full South, ſhaddoweth alwayes upon the houre of 12. in the Dyall; yet doth ſhe not alwayes come to the South at the houre of 12. and never, unleſſe in the day of her conjunction or oppoſition to the Sunne, and then at Mid-day in the one, and Mid-night in the other, or thereabouts; whereby it appeareth that for ſeverall dayes of the Moone, there muſt be (as it were) ſeverall Dyals, ſo contrived (on one and the ſame Plane) that each of them may readily ſhew the times of that night, unto which it properly belongeth: And therefore to proceede to our preſent purpoſe: you ſhall firſt prepare a ſquare peece of fitting and well ſeaſoned wood, that will not warpe or bend, or of braſſe, or other metall, or of ſtone, according as you ſhall pleaſe, which (for the more conveniencie in uſe) had need to containe in breadth about 12. inches; the larger it is, the better: Now, becauſe the Moone, in the day next after her change or conjunction, and likewiſe on the day next after her Full, or oppoſition to the Sunne, that is, ſhe being one day, and ſixteene dayes old, obſerveth the ſame (or much like) time in her comming

| *Age of the Moone.* | *Her comming to the Meridian.* | |
|---|---|---|
| *Dayes.* | *H.* | *M.* |
| 1 16 | 12 | 48 |
| 2 17 | 1 | 36 |
| 3 18 | 2 | 24 |
| 4 19 | 3 | 12 |
| 5 20 | 4 | 00 |
| 6 21 | 4 | 48 |
| 7 22 | 5 | 36 |
| 8 23 | 6 | 24 |
| 9 24 | 7 | 12 |
| 10 25 | 8 | 00 |
| 11 26 | 8 | 48 |
| 12 27 | 9 | 30 |
| 13 28 | 10 | 24 |
| 14 29 | 11 | 12 |
| 15 30 | 12 | 00 |

comming to the Meridian or Mid-heaven, and likewiſe being two dayes and ſeventeene dayes old, and ſo the reſt in their order, (as you may obſerve in this Table) but contrary or oppoſite times of the day; the firſt happening after-noone, that is to ſay, betweene Noone or Mid-day and the Mid-night following, and the other in the morning or before Noone, that is, betweene Mid-night and the Mid-day following: You ſhall therefore upon your ſayd Square or Plane, deſcribe fifteene Concentrique circles, ſerving for the thirty dayes of the Moone (or Synodicall moneth) of equall and convenient diſtance one from another, drawing the outermoſt circle as large as conveniently you can: So that circle which is next to the Center, ſhall moſt fitly ſerve for one day, and ſixteene dayes of the Moones age: the ſecond for two dayes and ſeventeene dayes: the third for three dayes and eighteene dayes: the fourth for foure dayes and nineteene: the fifth for five dayes and twenty dayes, and ſo all the reſt in their order, as the ſecond figure doth ſhew (but for the three firſt dayes of the Moone, there is ſeldome any uſe of the three firſt circles next the Center, becauſe it is moſt commonly the fourth day after the change, before ſhe ſhineth in the Horizon) then upon a large ſheete of paper or paiſt-boord, draw the common houre-lines of the Horizontall Plane, (out at length) according to the elevation of the Pole; and for the more conveniencie in the making of this Dyall, it is beſt to divide each houre-ſpace of the equinoctiall circle, by which you drew thoſe houre-lines into five equall parts, and then marking them out upon the line of contingencie, you ſhall by thoſe markes there made, draw out of the center of your houre-lines, obſcure radiall lines at length, which will accordingly divide each houre into five parts, and ſo each part will containe twelve minutes of an houre, by which diviſion you may readily and exactly ſet off on your Dyall any number of minuts ſet downe in the former Table, as pertaining to the houre of the Moones comming to the Meridian, as ſhall preſently be ſhewed: this being done, you ſhall upon the Center of your houre-lines ſo drawne, deſcribe fifteene obſcure Circles, equall to thoſe on your Plane, whereby you ſhall


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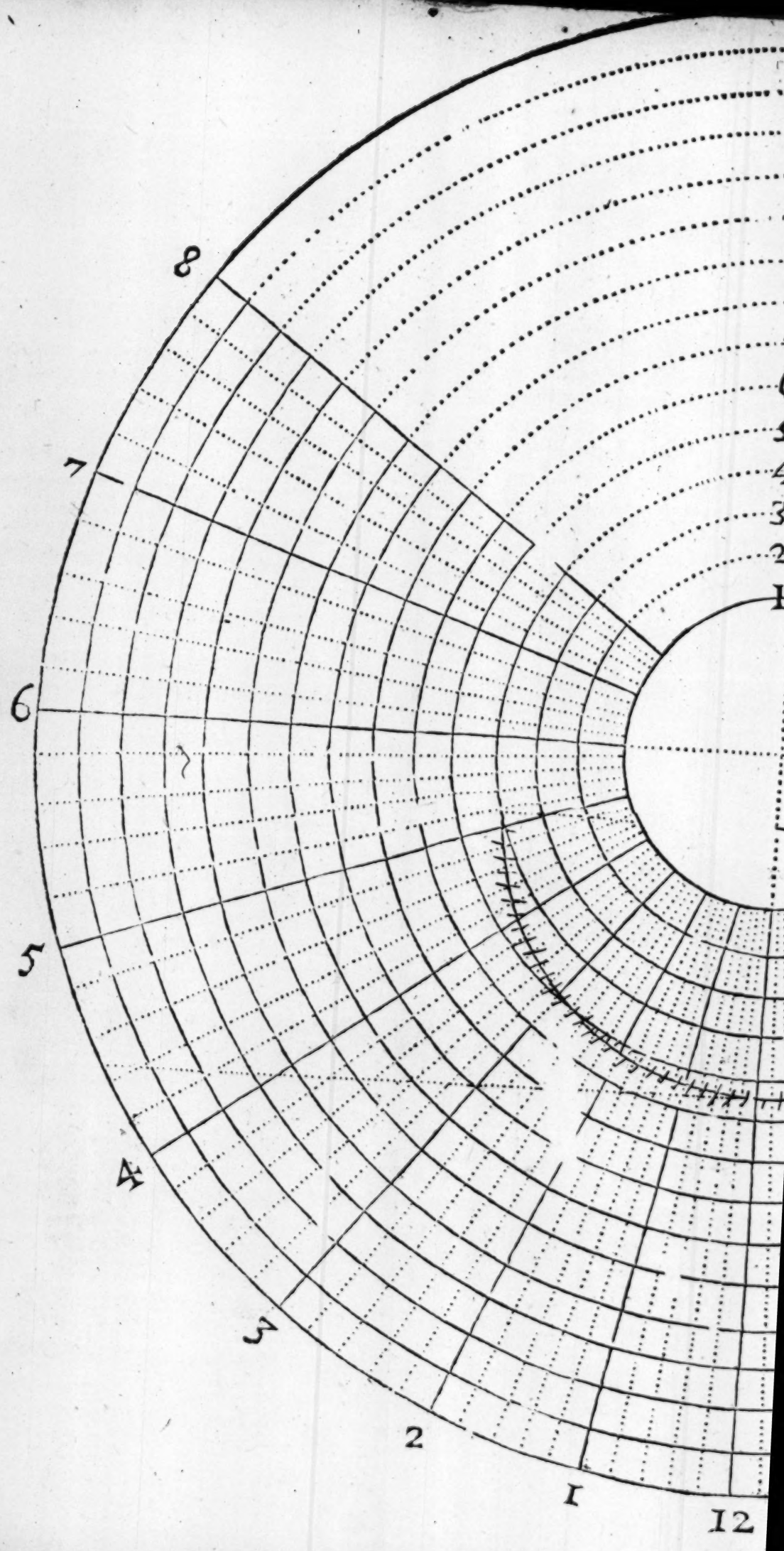

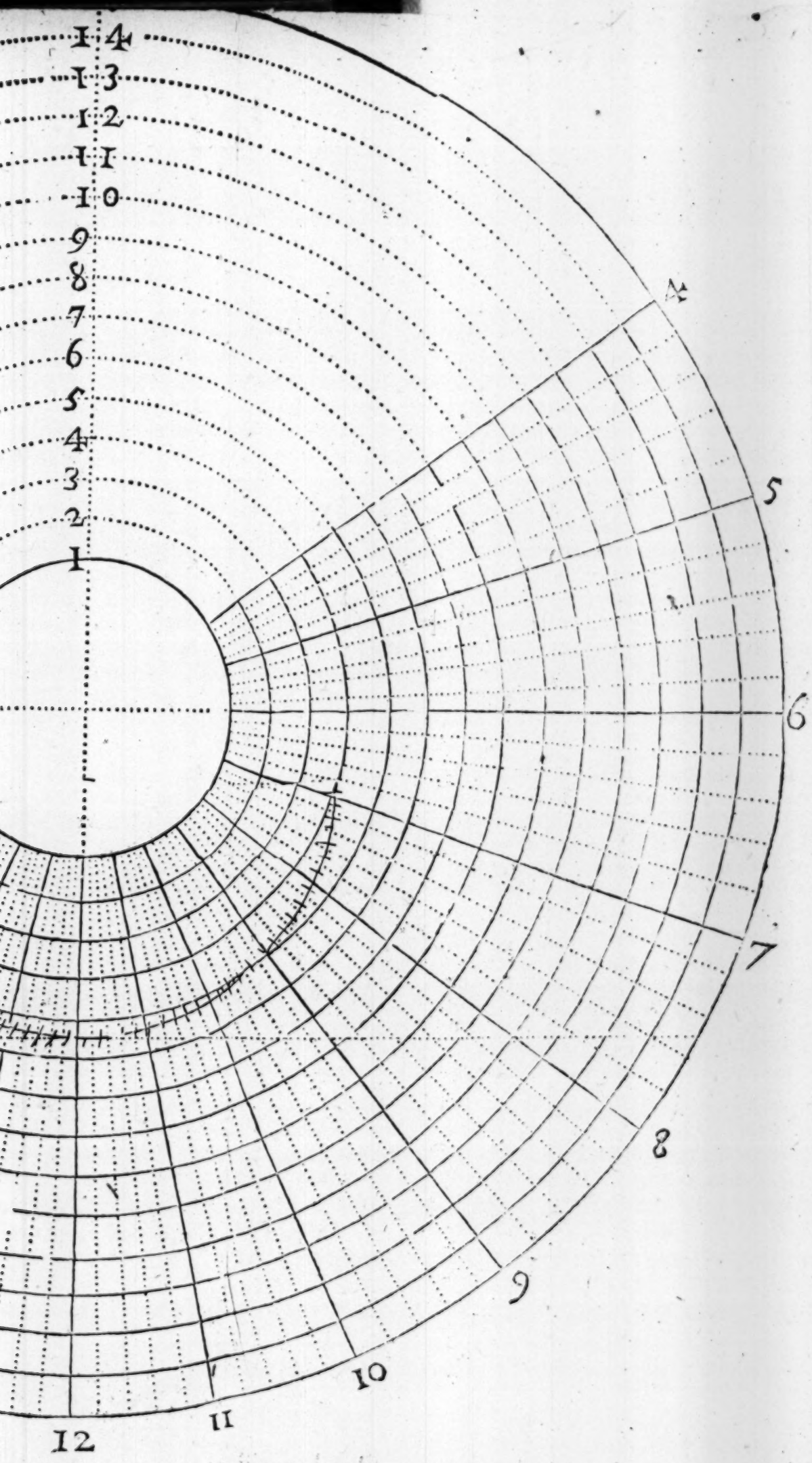


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ſhall ſet downē the houres and their parts upon ēvery Circle of your Plane, in their due poſition and diſtances one from another: All which things, this firſt figure doth demonſtrate, which although it may ſeeme unto many to be needleſſe, yet I have thought it convenient here to deſcribe the ſame for the better ſatisfying of ſuch as are not throughly experienced in theſe matters, and therefore doe deſire plaine demonſtrative inſtructions: theſe things being thus prepared, you muſt reſort to the former Table, and there finde the time of the Moones comming to the Meridian or South point, for any day of her age: So I finde that the Moone being at the age of one day, or ſixteene dayes, commeth to the aforeſayd place at 48. minutes after Mid-day in the one, and Mid-night in the other: whereupon the Meridian or 12. a clocke line in the firſt figure, doth not then repreſent the houre of 12. but 48. minutes paſt the ſame, and the houre-line of 11. 48. minutes paſt 11. likewiſe the houre-line of 1. 48. minutes paſt 1. and ſo all the reſt in their order: which being knowne, I ſet off the houres from the Meridian line after this manner: I take with my Compaſſes the diſtance betweene the houre of 12. in the Meridian line, and 48. minutes paſt the ſame, in the firſt circle on my houre-lines formerly drawne, being the next foure parts of the five, which are contained betweene the houre-lines of 12. and 1. or 12. and 11. (becauſe, as I ſayd before, each houre being divided into five parts, each of thoſe parts, will containe twelve minutes, and therefore foure of them 48. minutes, as the firſt figure ſheweth) then placing one foote of my Compaſſes in the Miridian line of the Plane upon the like circle; with the other I marke downe the houre of 12. towards the right hand: Alſo I take the diſtance betweene the houre of 12. (as before) and 48. minutes paſt the houre of 11. (being the next foure parts of the five, betweene the houre-lines of 11. and 10.) and ſetting one foote of my Compaſſes in the Meridian line of the Plane, with the other I marke downe the houre of 11. So I take 48. minutes or foure parts paſt the houre-lines of 10. 9. and 8. from the Meridian or 12. a clocke line of my houre-lines, to ſet downe the houres of 10. 9. and 8. from the Meridian line on the Plane; and

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ſo thé reſt on that ſide of the Meridian line: Then to placē the houre of 1. (and conſequently the reſt of the houres, which fall on the other ſide of the ſame line) I take the diſtance betweene the houre of 12. (as before) and twelve minutes paſt the ſame, being the firſt of the five parts betweene the houre-linēs of 12. and 1. (becauſe the houre of 1. falleth herē within twelve minutes of the Miridian) and with that diſtance I ſet downe the houre of 1. So I take twelve minutes or one part paſt the houre-lines, of 1. 2. 3. and 4. to ſet off the houres of 2. 3. 4. and 5. from the Meridian line on the Plane, and ſo all the other on that ſide of the ſamē line, as many as ſhall be needfull. Then to place the houres for two dayes and ſeventeēne dayēs of the Moone, I looke into the former Table, and therē I finde the time of her comming to the Meridian, to be at 36. minutes paſt one of the clock, afternoone in the one, and after Mid-night or in the morning in the other: which time muſt here be ſuppoſed to ſtand in the Meridian line in the place of the houre of 12. and therefore the houre-line of 11. muſt needes ſignifie 36. minutes paſt 12. and the houre-linē of 1. 36. minutes, paſt 2. and ſo all other before and after muſt ſignifie accordingly: wherefore placing one foote of my Compaſſes in the Meridian or 12. a clocke line (as before) on the ſecond Circle of mine houre-lines, I extend the other unto 36. minutes paſt the ſame, being the three next parts of the fivē betweene the houre-lines of 12. and 11. Then ſetting one foote upon the Meridian line on the Plane in the like Circle, with the other I pricke downe the houre of 1. towards the right hand. So I take 36. minutes or 3. parts beyond the houre-lines of 11. 10. 9. and 8. &c. to ſet down the houres of 12. 11. 10. & 9 &c. from the Meridian line on the planē. Then for the houres on the other ſide of this line, becauſe that here the houre of 2. falleth within 24. minutes of the South point: I take 24. minutes or two parts from the Meridian or 12. a clocke line of my houre-lines, and therewith I ſet downe the houre of 2. on my Plane: In like manner I take 24. minutes or two parts beyond the houre-lines of 1. 2. 3. and 4. &c. to ſet of the houres of 3. 4. 5. and 6. &c. Then for threē dayes and eighteene dayes of the Moone; I finde

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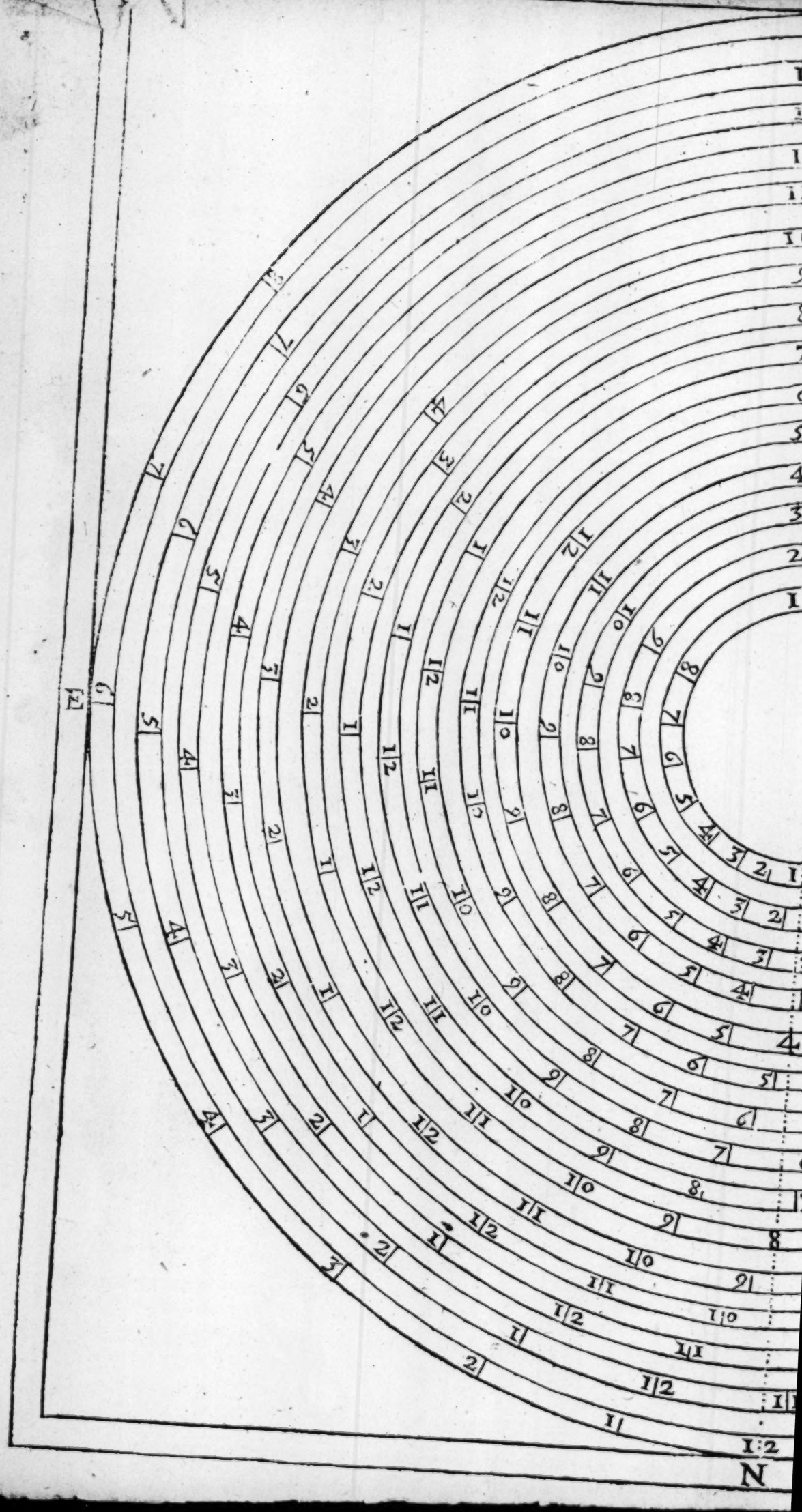

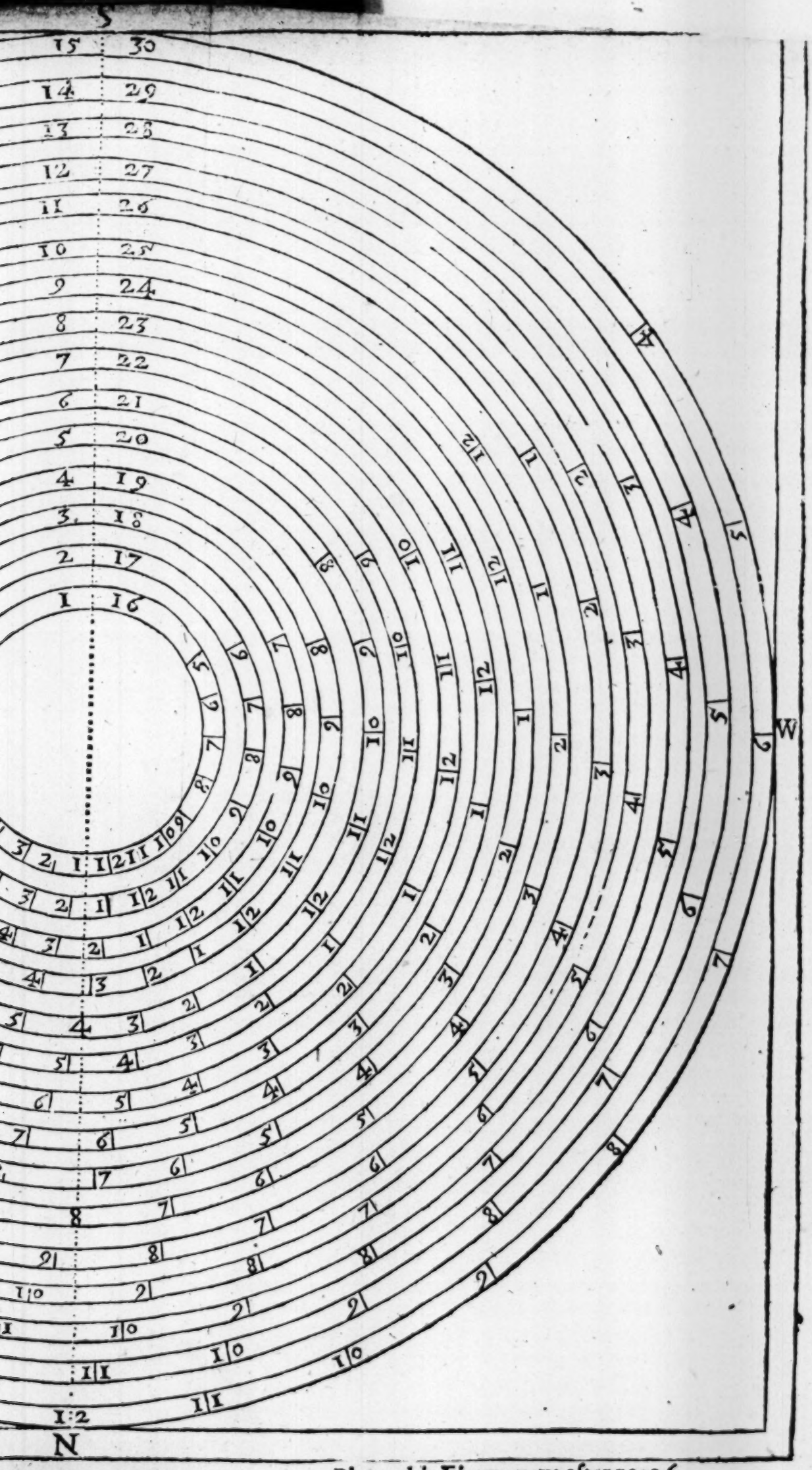


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finde by the former Table, that ſhe then commeth to the South at 14. minutes paſt two of the clocke after-noone in the one, and in the morning in the other: wherefore I take two parts beyond the houre-lines of 12. 11. 10 9. &c. in the third Circle upon my houre-lines, and therewith I ſet off the houres of 2. 1. 12. and 11. &c. from the Meridian line upon the like Circle towards the right hand: Then for the houres on the other ſide; becauſe that here the houre of 2. falleth from the Meridian or South point, by 24. minutes of time, on the one ſide thereof, therefore the houre of three falleth from thence on the other ſide by 36. minutes: wherefore I take 36. minutes or three parts beyond the houre-lines of 12. 1. 2. and 3. &c. and therewith I ſet off the houres of 3. 4. 5. and 6. &c. Then for the fourth and nineteenth dayes of the Moone; I finde that ſhe then commeth to the Meridian at 12. minutes paſt 3. of the clocke after-noone in the one, and in the morning in the other: wherefore I take one part (or 12. minutes) beyond the houre-lines of 12. 11. 10. 9. &c. upon the fourth Circle of mine houre-lines, and therewith I ſet downe the houres of 3. 2. 1. 12, &c. on one ſide of the Meridian line upon the like circle: Then becauſe the houre of 3. falleth here within 12. minutes of the Meridian on one ſide thereof, the houre of 4. will fall from thence on the other ſide by 48. minutes, and therefore I take foure parts beyond the houre-lines of 12. 1. 2. and 3. &c and therewith I ſet off the houres of 4. 5. 6. and 7. &c. Laſtly, to place the houres for the Moones age of five dayes, and twenty dayes, I looke in the aforeſayd Table; where I finde the time of her comming to the Meridian, anſwerable to thoſe dayes, to be juſt at foure of the clocke after-noone in the one, and in the morning in the other; which houre being placed in the Meridian line on the fifth circle from the Center; the houres on both ſides thereof, muſt be ſet off from thence, after the ſame

manner, as the houres are on both ſides of the houre of 12. when it ſtandeth in the Meridian line, (and therefore they doe fall preciſely upon the houre-lines for the Sun) becauſe (the angles being here unequall) the ſame angles muſt ſtill retaine the ſame places, otherwiſe great errours will enſue: All which things the ſecond figure plainely ſheweth: and in theſe five examples, are contained all the varieties of operations in this Dyall (in which I have beene ſomewhat the more tedious, to give the better contentment and ſatisfaction, to the more unlearned in theſe things) and therefore more examples would be altogether needeleſſe and ſuperfluous, the reſt being performed after the ſame manner: For the houres being noted downe in the five firſt Circles, (as wee have here ſhewed) the houres may be eaſily placed in all the other Circles, by the helpe of thoſe onely without the former operation: For you may obſerve in the working (and as the former ſecond figure ſheweth) that the houre-lines or points of the ſixth, and eleventh Circles, are in the ſame poſition (in reſpect of the Center) with the houre-lines of the firſt circle, and ſo the houre-lines of the ſeventh and twelfth circles, with thoſe of the ſecond, and thoſe of the eighth and thirteenth, with thoſe of the third, and thoſe of the ninth and fourteenth, with thoſe of the fourth, and likewiſe thoſe of the tenth and fifteenth circles, with them of the fifth circle: Whereby it is evident, that five circles onely might be ſufficient for this purpoſe, and then each circle ſhould containe three of the circles in the former figure, which are thus matched together in reſpect of their houre-lines, but differing in the numbers or figures belonging to the ſame, and hereupon each circle muſt ſerve for ſixe ſeverall dayes of the Moone: for the firſt circle from the center ſerveth for the 1, 16. 6, 21. 11, 26. dayes; (according as they are coupled togther in the former figure) the ſecond for the 2, 17. 7, 22. 12, 27. The third for the 3, 18. 8, 23. 13, 28.

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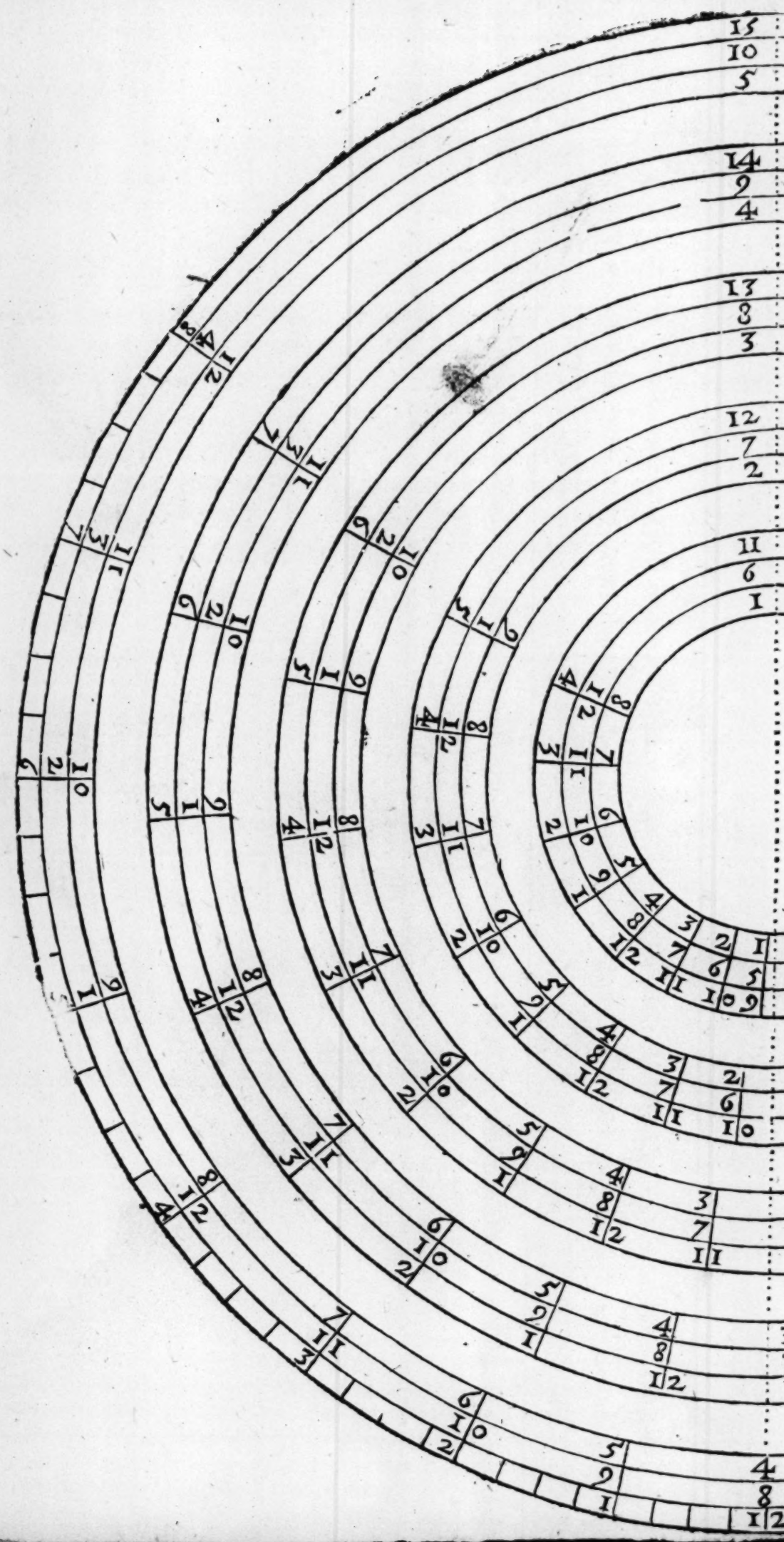

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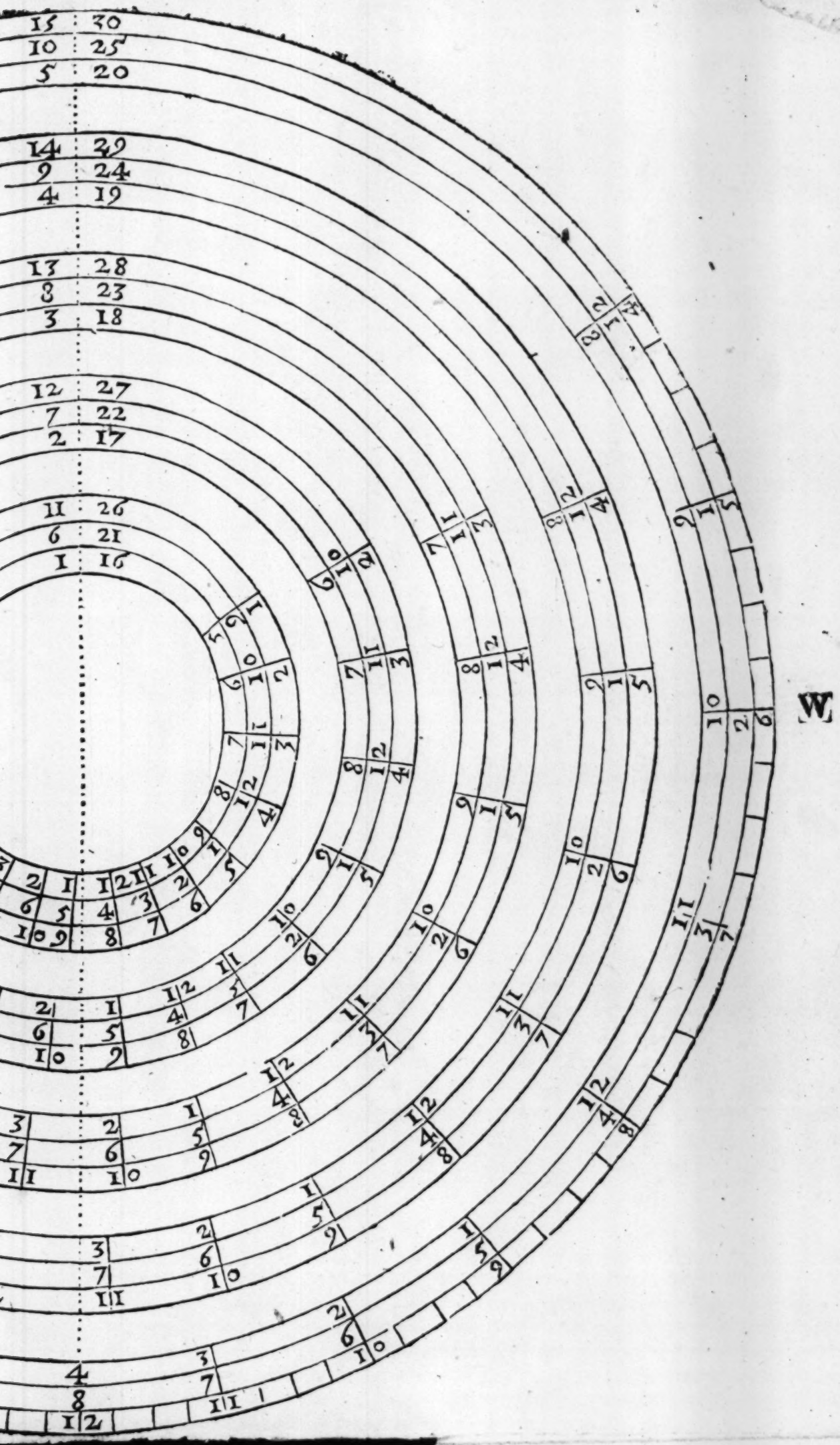
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The fourth for the 4, 19. 9, 24. 14, 29. The fifth and laſt for the 5, 20. 10, 25. 15, 30. which way, although it be ſomewhat more compendious for the making of the Dyall, yet more confuſed for the uſe thereof to the unskilfull, by reaſon of the manifold denominations of the circles and their houre-lines: for in the former figure each circle ſerveth onely for two dayes of the Moone, the one in her increaſe the other in her decreaſe, anſwering each other, in reſpect of the houre and minute of the Moones comming to the Meridian, and therefore (in that reſpect) there will fall out 15. circles, and ſo the houre-lines of every circle, are but of one ſimple denomination; but in this latter way, each circle containing three of the former, ſerveth for ſixe ſeverall dayes of the Moone (as I ſayd before) which doe anſwere one another, in reſpect of the number of minutes adhæring to the houre of the Moones ſayd comming to the Meridian, whereby it happeneth that the houre-lines which muſt ſerve for thoſe ſixe dayes, doe concurre on the Plane, and therefore may very fitly be contracted into one and the ſame circle on the Plane, but then the ſame houre-lines will beare a threefold denomination, as may be plainely ſeene in this third and laſt figure, which I have thought fitting here to be ſet downe, for the better conceiving of this latter way, being indeede a more compendious and compleate way than the former, that ſo, whoſoever ſhall make tryall of what is here delivered, may uſe that way which he ſhall beſt affect.

The houres in every Circle, are continued on both ſides of the Meridian line, ſo farre as the houre-lines for the Sunne doe extend, that ſo the Dyall might ſerve generally for all times of the yeare; and though the houre of 12. falleth twice in ſome of them, yet may they both be uſefull at one time of the yeare or other; for to place in ſuch houres onely as ſhall happen to be of uſe, and neither more nor leſſe, is a thing I conceive not to bee certainely

done by reaſon of the uncertaine riſing and ſetting of the Moone, and her uncertaine departure from the rayes of the Sunne.

Having noted downe the houres in every circle (as in the ſecond figure) adde to each circle one or two inward circles, making one or two convenient ſpaces for the placing in of litt'e lines or ſtrokes, for the houres and their parts (according to the uſuall manner) and the figures belonging to them: but in the latter way you muſt adde to each circle, three other inward circles, making three ſeverall ſpaces for the three rankes of figures belonging to every circle, (as you may ſee in the third and laſt figure) becauſe the houre-lines of every circle (as I ſayd before) be here of a threefold denomination: and it is neceſſary for you ſo to order and contrive the circles on your plane, as that there may be left a convenient ſpace betweene every ſeverall Dyall or circle of houres, to diſtinguiſh betweene them, and not to mingle and confound them one with another.

The parts of every houre neceſſary to be placed on the Dyall (though we have put none here, partly to avoyd tedioufneſſe in the worke, and ſome charge in cutting the figures, and partly becauſe they are needeleſſe in this place) may be thoſe which we have formerly uſed, or better it were for common uſe to have each houre divided into ſome equall number of parts, as foure or eight parts, as is uſually done in moſt Sun-dyals; for before we divided each houre into five parts, as being the fitteſt number for the more eaſie and exact making of the Dyall.

The outermoſt circle of all, belonging to the fifteenth day of the Moone or day of oppoſition, ſerveth aſwell for the Sunne, the houre-lines thereof being rightly diſpoſed for the Sunne. For the Moone, on the day of her coujunction with the Sunne, commeth to the Meridian much about the time that he doth, and in the day of her oppoſition

oppoſition to the Sunne, ſhe commeth to the ſayd place at the oppoſite time or thereabont, when the Sunne is in the North point of the Meridian circle, under the ear h, or our Horizon, that is, at our Mid-night or 12. of the clocke (as the former Table ſheweth) and then the ſame Dyall which ſerveth to ſhew the houre of the day by the Sunne, ſerveth likewiſe to ſhew the houre of the night by the Moone, though not alwayes ſo exactly, yet without any difference to be regarded in common uſe (as I have oftentimes obſerved) but at other times it cannot be ſo, becauſe the time of the Moones aforeſayd mediation or culmination, is not alwayes the ſame, but altereth on every day, and therefore that Dyall which ſhould ſerve to ſhew the houres or times of any other night by the Moone, muſt (of neceſſitie) be altered, and the houte-lines bee otherwiſe ordered and diſpoſed, or elſe why ſhould not the Moone in any night when ſhe ſhineth, ſhew the true houres thereof upon any true Sunne-Dyall by the ſtilar ſhadow, aſwell as the Sunne ſheweth the true houres of any day by the ſame; which thing, how farre it is from being ſo, I thinke there is ſcarcely no ordinary man that doth not know it; the reaſon thereof being (as I ſhewed before) becauſe the Moone doth not alwayes obſerve the ſame times with the Sunne, in her riſing, Southing, and ſetting.

Theſe ſeverall Dyals or circles of houres, may not onely be delineated upon the Horizontall Plane, to ſhew the time of the night by the Moone, but alſo upon all other planes by the ſame reaſon and rule, (and therefore we have here entitled it, *Lunar Horologiographie*, that is, *The Deſcription of Dyals for the Moone*) and moſt readily upon the Equinoctiall Plane, by reaſon of the equality of the horariall angles: And in the direct Meridian and Polar Planes, where the *Solar* houre-lines are parallels, there alſo the *Lunar* will be parallels; and in ſtead of thoſe fifteene concentricall circles formerly uſed, here muſt bee

fifteene parallell right lines, of which the equinoctiall line of the Plane, may very fitly be one, which may (if you pleaſe) ſerve for the fifteenth day of the Moone, and ſo will ſerve continually for the Sunne by the reaſon aforeſayd: So the ſeven Parallels falling under the ſayd line, may then fitly ſerve for the ſeven dayes next enſuing the day of her change and Full, and the ſeven Paralells above the ſayd line, for the ſeven dayes next before the Full, and the change next following: or you may begin at the uppermoſt parallell on the Plane, and account that for one day and ſixteene dayes of the Moone, and ſo going downewards, the loweſt parallell will be for fifteene and thirty dayes, and ſo for the Sunne, and then the equinoctiall line or middle parallell ſhall be for eight and 23. dayes, for you may begin with what parallell you will: then drawing the common houre-lines of theſe Planes, and dividing each houre into five parts (as before) the houres for the Moone are ſet off from the houre-lines of 6. in the one and 12. in the other on both ſides thereof upon their proper parallels, (as farre as the houre-lines for the Sunne doe extend) with as much facility as in any other Plane whatſoever, the Equinoctiall plane being excepted; ſo that you bee carefull to place the right houres in theſe planes: Having thus ſet downe the houres (and parts if you pleaſe) draw to each Parallell line another parallell including a convenient ſpace betweene them, wherein to draw little lines or ſtrokes for the houres and their parts, and to place the figures belonging to the houre-lines or ſtrokes: But for that I ſhewed before, how this might bee performed by five circles in the Horizontall plane, ſo by the ſame reaſon it may here be performed by five parallells onely, for then each parallell ſerveth for ſixe dayes, and the houre-lines of each parallell are of a threefold denomination, and then you muſt draw to each parallell line, three other parallels, that ſo there may be three fitting ſpaces made for the placing

cing of three rowes of figures which belong to the houre-lines of every parallell, as was done by circles in the Horizontall plane; and in the delineating of any of theſe Dyalls, it were convenient for you firſt to draw the common (or Solar) houre-lines belonging to the plane, obſcurely with the point of your compaſſe or ſuch like thing upon your plane, by which you may eaſily diſcerne whether you worke rightly or not: But to deliver any figure here concerning theſe laſt mentioned planes I thinke it to be needeleſſe, becauſe if the working upon the former be rightly underſtood, the working upon theſe latter and likewiſe upon all other Planes may eaſily be underſtood by the ſame reaſon: And as for the ſtile belonging to to theſe laſt named Planes, it is neceſſary that the ſame be made full as broad as the Plane of the houre-lines, (or if it were a little broader in the top, it were not amiſſe) that ſo the ſhadow thereof may alwayes extend as farre as the parallell lines on the Plane; for though a ſtraight round pin will ſerve in theſe Planes for a ſtile for the Sunne, yet it will not for the Moone, by reaſon of the varietie of Dyals on one and the ſelfe ſame Plane, all differing one from another: But indeed none other is ſo commodious for common uſe as the Horizontall Dyall, which may (moſt eaſily) be fitted for uſe two manner of wayes: For it may be either alwayes fixed abroad, like unto the common horizontall Sun-Dyall, and ſo be immoveable, or elſe not fixed, but to be removed up and downe at pleaſure, and then having a Magneticall Needle placed in a Boxe after the uſuall manner (whoſe Meridian line ought to be drawne therein, according to the deflection or variation of the Needle in the place of obſervation) to be affixed to ſome ſide thereof, it may bee truely placed thereby, any night when it ſhould be uſed, being holden or ſet preciſely horizontall; or (for want of ſuch a Needle) they that have an horizontall Sunne-Dyall about their houſe truely placed, may make a ſhift to uſe

it

it well enough, by laying it flat upon that Dyall, and then applying one side thereof to the side of the cocke or stile of that Dyall, in such sort that the Meridian line of the one may be paralell to the Meridian line of the other. But indeed the most absolute way of all, were to have it made in brasse (which may be done by Mr. *Elias Allen* dwelling without *Temple* Barre, over against St. *Clements* Church, *London*, who maketh all sorts of Mathematicall Instruments and also horizontall Sunne-Dyalls in brasse) and fixed alwayes upon a poast, or rather made upon a faire white stone, where the strokes for the houres and their parts and the figures belonging to them being done in blacke or other such notable colour, might be more perfectly discerned than in the other; So that then onely knowing the day of the Moone, (which may be knowne by any Almanacke) you have no more to doe, (the Moone shining on the Plane) but to looke out the circle which is appropriated to that day, and the shadow of the stile will presently give you the houre or time of the night, if your Dyall be rightly made and placed: And it would be very comely and convenient to have the stile to this Dyall made so, as it should touch the plane in those places onely where it is let into the same, that is, betweene the center and the circle next unto it, and againe a little about the outermost circle which is furthest from the center, that so the strokes for the houres and their parts, and the figures which fall upon or very neere the Meridian line, might not be hidden and defaced by the stile.

But because houre-lines may be placed generally upon all planes (as I sayd before) to shew the houres of the night by the Moone; it would be an excellent way to have a Lunar Dyall drawne on glasse and placed in a window after the manner of those Sunne-Dyalls which are most accurately made by my loving friend Mr. *Baptist Sutton*, dwelling at the upper end of *Chauncery* Lane, neere *Holborne* (being the author of the ensuing worke

or

or Addition) who likewiſe will be able to pẽforme theſe as accurately as the other, if it ſhall be required of him: For there the plane of the Dyall being of a tranſparent matter, and intercepted (as a meane object) betweene the eye and the Moone, the houre-ſtroakes and figures, together with the ſhadow of the ſtile, may bee thereupon more perfectly and ſpeedily diſcerned, than upon any other kinde of Plane whatſoever (and therefore I thought it not amiſſe to give notice thereof) but it is well knowne that the ſhadow which is cauſed by the Moone, cannot be altogether ſo perfectly diſcerned as that which is cauſed by the Sunne, becauſe the light of the Moone is not ſo perfect as the light of the Sunne, and therefore the time of the day may be ſomewhat more readily perceived on the Dyall by the ſtilar ſhadow, than the time of the night; yet it may be very eaſily diſcerned thereby, eſpecially when the Moone ſhineth out very bright.

And now, this our Horizontall Dyall I conceivẽ (and I thinke, that any man of underſtanding will acknowledge) to be farre more eaſie and ready in uſe, than that Lunar Dyall which Mr. *Fale* hath long agoe deſcribed, in his booke of *Solar Horologiographie*, whoſe poſition muſt be in direct Paralelliſme to the Equinoctiall circle of the Sphere, making the ſame angle (of inclination) with the Plane of the Horizon, which that doth, being the comp'ement of the Latitude or Polar altitude, and therefore but few men know how to make uſe thereof in compariſon of them that doe not know; and it muſt needes bee troubleſome alſo to thoſe that doe know how to place the ſame rightly, becauſe they muſt ſtand and apply a Quadrant together with a needle to it every night when they would uſe it, unleſſe the ſame ſtand alwaies fixed abroad in its due poſition; and if it ſo doe, yet the unskilfull ſort cannot well tell how to make uſe of it, by reaſon (it conſiſting of two ſeverall parts or plates) of the in-

inward moveable part thereof, turning about within the outmoſt plate, and upon which the houre-lines are drawne, whoſe Index, (or long tooth, as he termeth it) being faſtned at the houre of 12. muſt be turned to the day of the Moone noted on the outermoſt or fixed part, and to the houre of the change (as he ſaith) accounting from 12. of the clocke; in which he hath not ſufficiently expreſſed the meaning thereof, for ſuch as are but meanely skilled in theſe things, to underſtand, and ſo (as I conceive) hath not well declared the making and uſe of the ſame. Vpon the outermoſt or fixed part, hee draweth a circle, which hee divideth into 30. parts for the thirty dayes of the Moone, after this manner: Now becauſe (ſaith he) the Moone finiſheth her courſe in 29. dayes, 12 houres, and 44. minutes, (that is, from the Sunne, being in a meane conjunction with him, till ſhe be with him againe by the like conjunction) part or divide the aforeſayd circle into 30. parts, ſo as 29. of them being equall, the thirtieth or laſt muſt not be ſo great as one of the other parts by $\frac{1}{3}$, that is, it muſt containe $\frac{2}{3}$ of one of them; by which account (if it were true) the Moone ſhould finiſh her ſayd courſe in 29. dayes, and 16. houres, (which make $\frac{2}{3}$ of the naturall day) whereas the ſame is but 29. dayes, and 12. houres, or $\frac{1}{2}$ of the day naturall, and about $\frac{1}{4}$ of an houre over, and therefore it doth not conſequently follow, that the laſt part ſhould containe $\frac{2}{3}$ of one of the reſt, but rather $\frac{1}{2}$ onely: Indeed (for mine owne part) I muſt confeſſe, I never made tryall of this Dyall, and therefore can ſay the leſſe of it, neither doe I know whether the ſame were of his owne deviſing or not; But ſure I am that this our Horizontall Dyall is every way as exact as that, and ſerveth to a more generall uſe, it being of uſe and delight for all ſorts of men, and more eſpecially ſuch as know not how to finde the houre of the night artificially by other wayes: for if they can but know how to get the true age of the Moone (which

is eaſily done by an Almanacke, as I ſayd before) they may as eaſily obtaine the time of the night by this Dyall (or the like made upon any other Plane, when the Moone ſhineth thereupon; and that ſufficiently enough) as the time of the day by any Sunne-dyall when the Sunne ſhineth on the ſame: But if any liſt to make uſe of ſuch a kind of Dyall, as that of Mr. *Fales*, lately mentioned, they may uſe another way to finde the time of the night more exactly thereby: For the houre-lines being drawne upon the moveable or turning plate or wheele (as before is ſayd) which ſhould now be ſo large as each houre may be diſtinctly divided into ſuch a number of parts, as that you may gueſſe at any one minute thereupon, (which may conveniently 15. or 20. parts, for then each part will containe but foure or three prime minutes of time) If they can have a Table of the Moones comming to their Meridian artificially and exactly calculated for every day in the yeare, and ſo for every yeare ſeverally (which in ſome yeares is to be found in one Almanacke or other, if truſt may be given to them) then to make uſe of this Dyall in any night of the yeare when the Moone ſhineth, they muſt looke out that day in the ſayd Table, and right againſt it, under its proper moneth is ſet the houre and minute of the Moones comming unto the Meridian for that day and place: then the Dyall being rightly placed if they bring that houre and minute noted on the inward or moveable part to the Meridian line noted on the outtermoſt or immoveable part, and ſo let the houre-lines in that poſition, the ſhadow of the ſtile ſhall ſhew the houres of that night exactly, without having any regard to the dayes of the Moones age, noted upon the uppermoſt part, as in the former, and therefore this muſt needes be a ſurer way than the former, for that depending upon the houre or indeed the houre and minute of the Moones change (in which the Almanackes doe ſo much differ) muſt needes cauſe an errour in the obſervation of the

ime : and nēither this way nor the formēr, can be performed upon any Plane beſides the Equinoctiall, by reaſon of the inequality of angles in all other Planes, whoſe houre-lines make angles of interſection.

And now in the concluſion of this worke, thus much I ſay; that if the beſt inventions and conceits of men be haunted by ſome Momaicall Spirit at one time or other, as it is certaine they alwayes have beene and ſtill are: Then ſure I am, and I muſt not otherwiſe expect but that this of mine (being ſo meane in compariſon of many that have beene ſo haunted) will be in the ſame caſe; yet I may care the leſſe, becauſe the beſt of all have beene ſubject to *Momus* his cenſures: But whoſoever hee be, that ſhall carpe hereat, or evilly cenſure it; if he can finde out any other more exact way for this kinde of Horologiographie than that which I have conceited and here delivered (it having not beene done before by any, for ought that I doe know or could ever heare) as I doubt he cannot for the reaſons formerly alleadged; my requeſt to him is, that he would be pleaſed to beſtow a little paines in bringing of the ſame into light, and then I deſire, that for ever after, this may (as deſervedly it might) lye hidden in oblivion and dakeneſſe: In the meane ſeaſon I commit theſe my poore endeavours to the courteous and favourable acceptation of the friendly Reader and practitioner, ſaying to him, (concerning this matter) ſomewhat in effect as I ſayd before,

*Vive, vale, ſi quid noviſti rectius iſtis,*
*Extrahito in lucem; ſi non, his utere mecum.*

AN

# ADDITION CONCERNING THE MAKING AND VSE OF SEVErall plaine Scales, for the exact and moſt ſpeedy menſuration of Circles, Spheres, and Cylinders, and for Gauging of Veſſels.

1. FIrſt, a Scale for the taking of the diameter of any Circle, and thereby to finde the ſuperficiall content in foote meaſure.

2. The ſecond, a Scale for the taking of the Axis or diameter of any Sphere or Bullet, and thereby to finde out the ſolide content in inch meaſure: and if I had the true proportions of metals, I could have fitted a Scale for every ſeverall metall, ſo that the Axis of any Sphere or Bullet, being taken by his proper Scale and cubed, the cube ſhould be the weight of the Bullet or Sphere propoſed.

3. The third, a Scale or line for the finding of

the ſolid content of any Cylinder in foote meaſure, and that as ſpeedily as of any Paralellepipedon, by two multiplications onely.

4. The fourth a line or ſcale for the giving of the ſolid content of any Cylinder in wine gallons.

5. The fifth for the ſame in Ale Gallons, and theſe by two multiplications onely.

*The length of each Scale ſeverally as followeth.*

1. Firſt, the length of the Scale for taking of the diameter of a Circle is 1. 1283. foote, that is, one foote and 1283. parts of a foote divided into 10000. parts: This ſcale or line, and likewiſe all the reſt, muſt be firſt divided into ten equall parts and each of thoſe parts ſubdivided into ten equall parts (after the uſuall manner) and ſo the whole line or ſcale will containe 100. equall parts; or you may conceive each of thoſe laſt ten parts to be divided alſo into ten other parts, and then the whole line is ſuppoſed to containe 1000. equall parts; but indeed 100. parts will be ſufficient: Then knowing the length of every line or ſcale, you may take that in your Compaſſes, & turne it over upon a Ruler, as many times as you ſhall thinke to be fitting.

The length of the

| | | |
|---|---|---|
| 2. | *For the Axis of a Sphere,* | 1.2405. inch. |
| 3. | *For Cylinders.* | 1.0838. foot. |
| 4. | *For Wine meaſure.* | 6.65. inches. |
| 5. | *For Ale meaſure.* | 7. 02. inches. |

*The uſe of theſe ſeverall Scales briefely in their order.*

By the firſt Scale or line, having taken the diameter

meter of any Circle propoſed (whether in Pavement, Seeling, or the like) if you ſquare that diameter (the whole line repreſenting but one foote) the ſame ſhall be the ſuperficiall content of the circle in foote meaſure, as nearely as can be found by any other way whatſoever.

So if the diameter taken, be 4. 25. of the ſcale, the ſupernaturall content of the Circle will be 18. 0625. foote. The like may be done for inch meaſure.

2. By the ſecond ſcale, having taken the Axis or diameter of any Sphere or Bullet propoſed: if you cube that Axis; the ſame cube ſhal be the ſolid content of the Sphere or Bullet in inch meaſure.

So the Axis of a Sphere being 8.50. of his ſcale; the ſolid content will be found to be 614.125000. cubicall inches: the like may be made for foote meaſure.

3. By the 3. 4. and 5. ſcales; if the diameters and length be taken by their proper ſcales, and the ſquare of the diameter be multiplyed in the length, the product thereof ſhall be the ſolid content in foote meaſure, Wine gallons or Ale gallons, according to the qualitie of the ſcale and meaſure.

So if the length of a Cylinder be 12.00. by the third ſcale, and the diameter 1. 75. the ſolide content thereof will be found to be 16.7500. cubique feete: the like for inch meaſure.

*Rules*

## *Rules for Gauging of Veſſels.*

It is generally holden (and I my ſelfe have found by ſeverall trialls) that a wine Gallon conteineth 231. cubicall inches, or very neare thereupon; and that an Ale Gallon conteineth 272 $\frac{1}{4}$ cubicall inches in liquour.

### *The* 1. *Rule.*

This rule is the beſt and certaineſt of all other, and the way to prove other rules by, becauſe it is grounded upon good demonſtration, but withall it is ſomewhat tedious: See Mr. *Oughtreds* booke of the Circles of proportion.

The Rule is thus.

Adde the $\frac{1}{3}$ of the Circle at the head, to $\frac{2}{3}$ of the Circle at the bongue in inches; the ſumme of this addition being multiplyed by the length in inches, giveth the ſolide content in cubique inches, which being divided by 231 (if wine meaſure) or 272 $\frac{1}{4}$. (if Ale meaſure) the quotient is the content in Gallons.

The readieſt way for the finding of the $\frac{1}{3}$ and $\frac{2}{3}$ of the ſuperficiall contents of circles at the head and bongue, is this.

1. As 1. is to 0.5237.

So is the ſquare of the diameter at the bongue to $\frac{2}{3}$ of the circle at the bongue.

2. As 1. is to 0.2619.

So is the ſquare of the diameter at the head, to $\frac{1}{3}$ of the circle at the head.

Theſe

Theſe $\frac{2}{3}$ and $\frac{1}{3}$ added together, make thē meane Circle, whoſe diameter may (not unfitly) be called a meane diameter: and thus much for the firſt.

*The 2. Rule.*

1. *How to finde the meane or equated diameter which is thus.*

Multiply the difference of the Diameters by .7, and adde the product to the diameter at the head; the ſumme thereof is the equated diameter.

*Example.*

Diameter at the { *Bongue*, 35.25. } diff. 6.65.
{ *Head*, 28.60. } .7
4.655.

*Equated* 33.255. *diameter.*

2. *To finde the Content of any Veſſell in Gallons.*

Firſt finde the equatēd diameter, and ſquare it; Then firſt by inch meaſure.

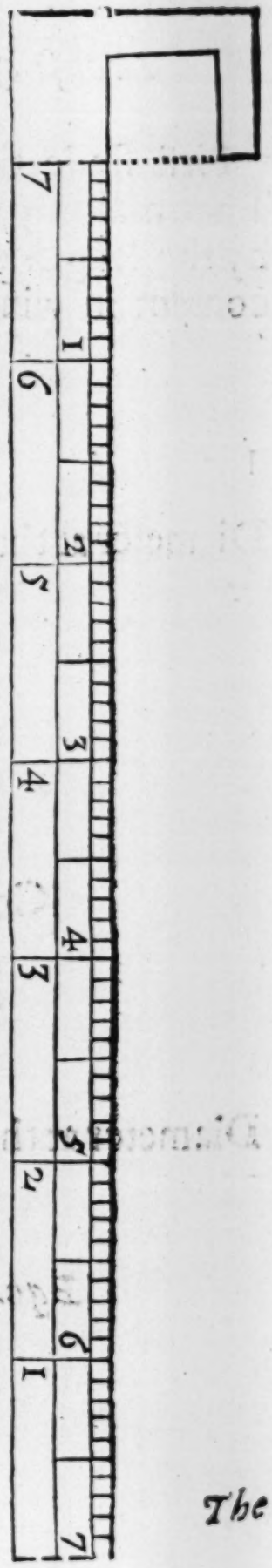
As 294. (if Wine meaſure) or 346.5. (if Alē meaſure) are to the length in inches: So is thē ſquare of thē equated diameter, to the contēnt in Gallons.

The rēaſon of theſe two numbers, is the ſame with that of a Circle to its circumſcribing ſquare, that is, as 11. to 14. wherefore, if the cubique inches contained in a Gallon be augmented by 14. and the product divided by 11. the quotient will yeeld a number, which ſhall be the Diviſor. Now for the triall of this rule: Suppoſe a veſſell to be in length. 39.9. inches, the head, bongue and equated diameter as before; the ſquare of the equated diameter is 1105.9. which multiplyed in the length, giveth 44125.41. cubique inches, which divided by 294. (if Wine meaſure) giveth in the quotient 150.08. Gallons of Wine: but by the ſcale enſuing, the ſayd veſſell would containe but 149 $\frac{1}{3}$. So is the difference about $\frac{2}{3}$ of a Gallon, which being ſo ſmall, is not to be regarded in the Art of gauging.

The third way which I havē found out for the more ſpeedy working herein, is by a ſcale or line of equall parts onely, having reference to none other line in the taking of the meaſures: yet (if you pleaſe) you may make uſe of Maſter *Gunters* line of numbers, or the Table of Logarithmes in the caſting up of the contents: or you may worke by naturall or decimall Arithmetique, as ſpeedily, as ever hath beene ſhewed by any ſcale heretofore publiſhed: neither am I ignorant of Maſter *Oughtreds* Ruler, where he uſeth two lines; the one of inches, and the other of unequall parts. But to come to the purpoſe: This ſcale or line, is the fourth in place formerly mentioned, the ſcale

it

it ſelfe being *6.65.* inches, which length being taken with a paire of compaſſes from a line of inches (where the inch is divided into an 100. equall parts) may be turned over *6.* or 7. times (or more or leſſe, as you ſhall thinke to be moſt convenient) upon a rod or Ruler, having an hooke at one end thereof, according to the uſuall manner, and then beginning right under the end of the ſayd hooke, runne the diviſions towards the other end, and ſet thereunto the figures, 1. 2. 3. 4. &c. from the hooke towards that end, and ſet them likewiſe backwards from thence towards the hooke, as this preſent figure ſheweth: Or you may allow ſomewhat for the thickeneſſe of both the heads of the Veſſell, from the place right under the hooke, if you ſhall think it fitting. Every ſuch part of the Ruler muſt be divided into 100. equall parts; ſo will it be made fit for this purpoſe: You may (if you pleaſe) place the line for Ale meaſure, and alſo the line of numbers thereupon, which may there ſerve for ſome uſe as occaſion ſhall require.



*The vſe of this Gauging Ruler is thus.*

Firſt finde the equated diameter, as beforē: Then multiply the ſquare of the equated diameter by the length of the veſſell; the product is the content in wine Gallons.

*Example.*

Diameter at the { *Bongue*, 5 .3. } diff. 1 .0.
{ *Head*, 4 .3. } .7.
.70

*Equated* 5 .00. *diameter.*
5 .00.
Square 25 .00.
Length 6 .00.
Content 150 .00. in Gallons.

*Another Example.*

Diameter at the { *Bongue*, 5 .35. } diff. .85.
{ *Head*, 4 .50 } .7.
.595

*Equated diam.* 5 .095
5 .095
25 475.
458 55.
25475

Square

| | | |
|---|---|---|
| Square of the Length | 25.959025.<br>6.25. | Equated diameter: Or I might here take 26, because the fraction approacheth nigh unto an unitie: for in this kinde of mixt numbers, |
| | 129795125.<br>51918050.<br>155754150. | |
| *content in gallons.* | 162,24390625 | |

when the last figure of the fraction towards the left hand exceedeth the number of 5. there (to avoyd the fraction) you may adde an unitie to the whole part thereof, and so make it an absolute number, and when it wants of 5. (as in the last fraction) you may (if you please) reject the fraction (which will breed no sensible errour in the worke) and retaine the whole number onely, or you may cut off all the figures (if there be many) saving the last two or three towards the left hand, and so make it onely a centesimall or millesimall fraction: So the fraction of the last number aforegoing, may be onely .24, which here signifieth very neare $\frac{1}{4}$ of a Gallon.

The question in this last example, is as difficult as most that you shall meete with of this kind, and therefore if this be rightly understood, all other questions of the same nature may be easily understood.

Here I might have shewed the use of some other scales for this purpose, and likewise the manner of taking the diameters of vessels at the head and bongne by this Ruler, but that this is a thing

not unknowne to ſuch as are exerciſed in gauging of Veſſels, the ſame being fully ſhewed in bookes of gauging already publiſhed: and therefore mine intention was not, here to ſet downe the whole Art of gauging, but briefely to ſhew the making and uſe of this gauging Ruler, which was never publiſhed before, although I could have ſet forth the ſame long before this time; and therefore if any ſhall thinke good to make tryall of this or any of the reſt which I have here delivered, let them ſpeake of them according to what they ſhall finde in them, and not otherwiſe.

*Theſe two ſeverall workes* (friendly Reader) *contained in this booke and ſo preſented to thy view, being (each of them) but of a ſmall quantity, and alſo as novelties, we have therefore thought it meete and commodious thus to connect them.*

FINIS.

## *ERRATA.*

PAge 4. line 3. read, but at contrary. p. 5. l. 2. r. poſitions. l. 28. r. Meridian. p. 16. l. 29. read this his dyall. p. 17. l. 14. r. conveniently be 15. or 20. l. 28. for let r. ſet. p. 21. l. 8. for ſupernaturall r. ſuperficiall. l. 21. r. lengths.